Draft Technical Support Document for HWC MACT Standards

Volume V:
Emissions Estimates and Engineering Costs

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Contents

Acronyms

AC	Annualized cost
APCD	Air pollution control device
AWFCO	Automatic waste feed cutoff
A/C	Air to cloth ratio
BTF	Beyond the floor
CB	Cabon bed
CE	Cost effectiveness
CEMS	Continuous emissions monitoring system
CI	Carbon injection
CK	Cement kiln
CMS	Continuous monitoring system
DL	Design level
DOM	Design, operating, and maintenance
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
ESP	Electrostatic precipitator
FF	Fabric filter
HAP	Hazardous air pollutant
HEWS	High energy wet scrubber
HWC	Hazardous waste combustor
ISR	Interim Standards Rule
IWS	Ionizing wet scrubber
LEWS	Low energy wet scrubber
LFB	Liquid fuel boiler
LVM	Low volatile metals
LWAK	Lightweight aggregate kiln
MACT	Maximum Achievable Control Technology
MDOM	Medium improvement in design, operation, and maintenance
MTEC	Maximum theoretical emission concentration
O&M	Operating and maintenance
PCDD	Polychlorinated dioxins
PCDF	Polychlorinated furans
PM	Particulate matter
Q	Quench water spray cooling
SDOM	Small improvement in design, operation, and maintenance
SFB	Solid fuel boiler
SRE	System removal efficiency
SVM	Semivolatile metals
TAC	Total annualized cost
TCl	Total chlorine
TEQ	Toxic equivalent

1.0 Introduction

The United States Environmental Protection Agency is proposing "Maximum Achievable Control Technology" (MACT) standards for "hazardous air pollutants" (HAPs) for hazardous waste combustors (HWCs). This includes hazardous waste burning incinerators, cement kilns, lightweight aggregate kilns, boilers, and hydrochloric acid production furnaces. The MACT standards for the "Phase I" hazardous waste burning incinerators, cement kilns, and lightweight aggregate kilns will replace the interim standards promulgated for these sources on February 13 and 14, 2002 (67 FR 6792 and 67 FR 6968). The MACT standards for "Phase II" hazardous waste burning categories – boilers and hydrochloric acid production furnaces – will be proposed (and promulgated) on the same schedule as the replacement Phase I standards.

This document presents: (1) national emission estimates for the HAPs (and HAP surrogates) regulated by the MACT rule, and (2) engineering and compliance cost estimates for affected sources to comply with the MACT standards. The document contains the following chapters:

Chapter 2: MACT Options – Presents the various MACT options that are evaluated.

Chapter 3: National Emissions Estimates -- Presents procedures for and results of estimating emissions for HAP and HAP surrogates for each of the MACT options.

Chapter 4: Engineering Costs -- Presents procedures for and results of estimating the engineering costs for each of the MACT options.

Chapter 5: Other Compliance Cost -- Discusses compliance costs for MACT performance testing, continuous performance monitoring, and recordkeeping and reporting requirements.

Chapter 6: Non-Air Impacts -- Summarizes non-air environmental impacts of the MACT options, including those for water, solid waste, energy, and waste minimization.

Chapter 7: Miscellaneous Issues – Discussion of: particulate matter size distribution.

2.0 MACT Regulatory Options

2.1 Existing Sources

Floor Options

Compliance costs and emissions reductions are evaluated for three MACT floor options. The floor standards for existing sources for each HAP and source category for each of the three options are shown in the first three tables of Appendix A:

- **Option 1**: Metals (mercury (Hg), semivolatile metals (SVM), and low volatile metals (LVM)) and chlorine floors are set using the "SRE-Feedrate" analysis procedure. This involves ranking source performance based on consideration of both "front end" feedrate control and "back end" system removal efficiency (SRE). Floors are determined based on stack gas emissions levels from the best ranked sources (i.e., those with the lowest combination of feedrate and SRE ranks). Similar to Option 2 discussed below, PM floors are determined using the "Control Technology" approach. Similar to Options 2 and 3 discussed below, PCDD/PCDF floors are evaluated using the "Emissions" approach.

- **Option 2**: Option 2 is similar to Option 3 discussed below, with two exceptions:

  - Floors for metals (Hg, SVM, and LVM) and chlorine for the "energy recovery units" (cement and lightweight aggregate kilns and liquid boilers) are set using "thermal emissions" (where stack gas emissions are normalized by the energy content of the hazardous waste feed).

  - PM floors are determined using the "Control Technology" approach, where sources are ranked according to their relative PM control technology performance.

- **Option 3**: All floors are set using the "Emissions" approach. Sources are ranked by stack gas concentration emissions levels. The floor for each HAP is determined from the emissions of the top 12 percent ranked sources (i.e., the 12 percent of systems with the lowest emissions of each HAP).

For a detailed discussion of the procedures considered for evaluating the MACT standards, see the preamble language and "Draft Technical Support Document for HWC MACT Standards, Volume III, Selection of MACT Standards", March 2004.

The numbers shown in parenthesis in the Appendix A tables are the "design" levels (DL) that are used for costing and emissions estimates. The design level is an estimate of the stack gas concentration that is required to meet the full standard, considering variability inherent in measurement methods and source performance. The DL is the level that a source with typical variability is expected to design and operate at to confidently meet the full standard. The design level that is used is the lower of: (1) the average of the MACT pool sources used to set the floor standard; or (2) 70% of the full standard.

Beyond the Floor Options

Three “beyond-the-floor” (BTF) options are also considered for each of the three floor options:

- A: Floor option, with additional BTF for PM for solid fuel boilers (SFBs) of 0.03 gr/dscf.

- D: BTF Option A, with additional BTF’s for PCDD/PCDF for lightweight aggregate kilns of 0.4 ng TEQ/dscm, HCl production furnaces of 0.4 ng TEQ/dscm, and liquid fuel boilers with dry APCDs of 0.4 ng TEQ/dscm; and BTF’s for total chlorine of 150 ppmv for LWAKs, and 110 ppmv for SFBs.

- E: BTF Option E, without the BTFs for total chlorine for LWAKs or SFBs.

2.2 New Sources

Floor levels for new sources for each of the three options are shown in the last three tables of Appendix A.

3.0 Emissions Estimates

Emissions estimates are presented for:

- Current – Current, existing operations – before the ISR (Interim Standard Rule) or HWC MACT replacement rule.

- Interim Standards Rule – As a result of the HWC Interim Standard Rule (ISR), applicable to Phase I units (cement kilns, lightweight aggregate kilns, and incinerators).

- MACT Replacement Rule – As a result of each of the HWC MACT Replacement Rule options, discussed previously in Chapter 2.

Emissions levels are provided for the following HAPs:

- Hydrogen chloride (HCl) and chlorine gas (Cl_2), and the combined total chlorine (TCl);

- Polychlorinated dioxins and furans (PCDD/PCDF) expressed as toxic equivalency (TEQ);

- Mercury (Hg);

- Semivolatile metals (SVM) including cadmium (Cd) and lead (Pb);

- Low volatile metals (LVM) including arsenic (As), beryllium (Be), and chromium (Cr);

- Other non-enumerated HAP metals including cobalt (Co), manganese (Mn), nickel (Ni), antimony (Sb), and selenium (Se); and

- Other RCRA metals including barium (Ba) and thallium (Tl).

Emissions levels are also provided for the following HAP surrogates: particulate matter (used as a surrogate control for the non-enumerated metals); and hydrocarbons (HC), carbon monoxide (CO), and destruction and removal efficiency (DRE) (used as surrogate control for non-PCDD/PCDF organic HAPs).

3.1 Procedures to Set Current Existing Emissions

3.1.1 HWC Data Base

Information from the HWC Data Base, presented in Technical Support Document Volume II, is used to set current, existing emissions profiles for each HWC system. The HWC Data Base contains stack gas emissions, feedstream characteristics, and other combustor information from trial burn, risk burn, and Certification of Compliance test reports that were collected in early 2002. The Data Base was released in mid 2002 for stakeholder review and comment. The Data Base was then revised based on comments and additional information submittals. Specific responses to the stakeholder comments are provided in Appendix D of the Technical Support Document Volume II. The set of sources includes those combustors that were burning hazardous waste during the early 2003 time period.

3.1.2 Data Selection Priority

As available, HAP stack gas measurements taken from the specific source are used to represent the current performance:

- Compliance test – As a first priority, data taken from "compliance test" flagged conditions are used. As discussed in Technical Support Document Volumes II and III, compliance test conditions are those from CoC or trial burn testing programs which are used to demonstrate compliance with the HAP emissions standard and used to set operating limits for the specific HAP.

- In-between – If compliance test rated conditions are not available, "in-between" flagged conditions are used.

- Normal -- If compliance test or in-between conditions are not available, data from "normal" flagged test conditions are used.

- Others – If compliance test, normal, or in-between flagged test conditions are not available, data are "imputed", as described in the next section. Data from conditions that are flagged as "NA" are not considered for determining current emissions.

For many of the Phase I sources, two or more test reports from different testing dates (typically separated by 3 to 5 years) are contained in the database. In these cases, emissions data and information from the most recent trial burn or compliance test report are used to represent emissions from the source. This is because the emissions data from the most recent test condition best represents current operations.

3.1.3 Imputation

Emissions estimates are "imputed" when appropriately rated stack gas measurements are not available from the specific source. Stack gas emissions concentrations are imputed (e.g., ug/dscm, ppmv, mg/dscm). Mass emissions rates (e.g., g/hr, lb.hr) are determined by multiplying the imputed stack gas concentrations by the stack gas flowrate. Imputation is used for emissions and cost estimation purposes only; imputation is not used for the MACT floor-setting process presented in Technical Support Document Volume III.

HAP Stack Gas Concentration

Imputation procedures vary depending on the HAP and source category. Imputation is generally based on an engineering assessment of the best available data that impact HAP emissions. The specific imputation procedure involves:

- For liquid fuel boilers, total feedrate "maximum theoretical emission concentrations (MTECs) for metals, chlorine, and ash are used to estimate metals, chlorine, and PM emissions:

    - -- When the unit does not have any active air pollution control device, the emissions level is assumed to be equal to the feedrate (SRE = 0%).

    - -- When the unit does have an active air pollution control device (such as a wet scrubber or fabric filer), emissions are projected based on the feedrate MTEC and a randomly imputed SRE that is taken from SREs measured at facilities with similar-type air pollution control devices.

  When HAP feedrate levels are reported as "non-detect" (at a level less than the detection limit), stack gas emissions levels are estimated assuming that the HAP is present at one-half of the detection limit.

- For units other than liquid boilers (and for liquid boilers when a feedate MTEC is not available), when PCDD/PCDF, metals, chlorine, and PM stack gas measurements are not available for the specific source, emissions are randomly imputed from the pool of data that are available from the set of sources which use similar design and operations, grouped according to:

    - -- Source category type, with six separate categories including incinerators, cement kilns, lightweight aggregate kilns, solid fuel boilers, liquid fuel boilers, HCl Production Furnaces; and

    - -- Air pollution control system type:
        - For PM, three sub-categories of (1) no PM APCD, (2) FF or ESP, or (3) other (wet scrubber).
        - For chlorine and Hg, two sub-categories: (1) no chlorine or Hg APCD; or (2) dry or wet scrubbing.
        - For PCDD/PCDF, three sub-categories: (1) dry APCD (imputed as a function of APCD operating temperature from two groups – < 400°F, and > 400°F), no waste heat boiler; (2) waste heat boiler; or (3) wet scrubbing or no PM APCD.

Also:

- Imputation is performed independently for each HAP. Imputation is not done on a "vector" basis, where a group of measured parameters from one source is assigned to another source that was missing these information. This type of “vector” imputation is not appropriate because:

-- The pool of data and information that could be potentially imputed from would be severely limited to only the sources that measured all the needed (missing) HAPs. This would limit the representativeness of the data set used for imputation.

-- There is a weak correlation among the concentrations of each HAP in the hazardous waste – the concentration of beryllium in a hazardous waste is not dependent on and therefore not correlated to the concentration of arsenic in the hazardous waste.

Therefore, imputation is performed for each HAP individually from the appropriate source / control practice grouping.

Stack Gas Flowrate

Stack gas flowrates are available for almost all units. For the units for which stack gas flowrates are not available, stack gas flowrate has been estimated based on unit firing rate, capacity, and/or waste feedrate input, using a typical waste “F-factor” of 10,000 dscf of stack gas generated per / MM Btu heat input.

Stack Height and Diameter

Stack heights and diameters are imputed using a stratified approach involving randomly selecting a source from a pool of sources with stack height and diameter information within a similar range of stack gas flowrates. This approach is appropriate because there is a general relationship between the size of the source (as represented by the stack gas flowrate) and its stack height and diameter.

3.1.4 Adjustments for Emissions Data Operating Condition Classification

As discussed above, emissions data are potentially from tests classified under three different types of operating conditions:

- “Compliance test” – Data taken under “stressed” permit limit setting operating conditions.

- “Normal” – Data taken under “normal”, typical, non-stressed operating conditions.

- “In-between” – Data taken under operating conditions somewhere between “compliance test” and normal.

The data are adjusted to a common operating condition, depending on the basis of the specific MACT standard:

- Standard based on compliance test data – For most of the standards which are based on compliance test data, "normal" and "in-between" data are adjusted (projected) up to "compliance test" operating conditions by:

  -- Normal – Increasing normal data by a factor of 3 to account for maximum expected "compliance test" emissions levels. It has been suggested by stakeholders that emissions under maximum operating limits can typically be 3 times higher than emissions under normal operations.

  -- "In-between" – To estimate maximum compliance test levels, "In-between" emissions levels are increased by a factor of 1.5.

- Standards based on normal test data – A few standards are based on "normal" data -- specifically, Hg for LFBs, CKs, and LWAKs; and SVM for LFBs. In these cases, compliance test and in-between test condition data are adjusted downward to estimate "normal" emissions by reducing them by a factor of 3 for compliance test data and 1.5 for in-between data.

3.1.5 Annual Mass Emissions

Mass emission rates for each HAP are estimated from every HWC system using the measured (or imputed) HAP emission concentration and stack gas flow rate, as determined in the above described procedures.

Annual emissions rates are calculated assuming that on average, each facility operates 8,000 hours/yr (91% of the possible maximum operation). For some sources which operate intermittently, this may result in an overestimation of yearly emissions levels. However, for the majority of sources, a 90% uptime is typical of normal operations.

For HAPs for which the MACT standard (and current existing emissions profile) is based on data from compliance test operating conditions (used to demonstrate compliance and set operating limits), the annual emissions estimates are likely an upper bound on actual emissions – i.e., emissions during actual operations are likely lower than the emissions shown based on compliance testing operating conditions.

Alternatively, for HAPs where the MACT standard is based on "normal" data (Hg for LWAK, CK, and LFBs; and SVM for LFBs, annual emissions estimates are also representative or "normal" operations.

3.2 HWC Sources and Stack Conditions

The first table in Appendix B shows general information for each HWC system, including: HWC Data Base System Identification Number (System ID), EPA RCRA ID No., facility / company name, location (city, state), combustor source category type, and air pollution control system (for the list of control device acronyms used, see Technical Support Document Volume II).

The second table in Appendix B shows stack information for each HWC, including: stack gas flowrate, velocity, temperature, moisture, and oxygen, and stack diameter and height.

3.3 Emissions Estimates

3.3.1 Current, Existing

The first table in Appendix C shows "Current, Existing" emissions levels for each HWC system. The table includes the following information for each system and each HAP:

- Test condition ID No. – Test condition ID No. from the HWC Data Base from which the stack gas emissions level is taken from.

- Classification of the test condition – Type of test condition for which the emissions data come from: compliance test (CT), normal (N), or in-between (IB).

- Stack gas emissions concentration and mass emissions rate.

- Origin of emissions estimate – Identifies the source of the stack gas emissions level:

  - "M" – Actual stack gas measurement at the specific combustor system.

  - "I" – Imputed from an actual measurement from a group of similar type systems, as discussed above. In this case, an actual stack gas measurement from the specific system is not available.

  - "F" -- Stack gas emissions are estimated from an actual measured feedrate MTEC.

  - "E" – Fraction of another measured or imputed value (Cr+6 as a fraction of Cr (total)).

- Stack gas flowrate and oxygen – Used to convert stack gas concentration to mass emissions rate.

3.3.2 Interim Standard Rule Baseline

For Phase I systems (incinerators, cement kilns, and lightweight aggregate kilns), the baseline is determined at levels projected for compliance with the "Interim Standards Rule"

(ISR). For Phase II systems (liquid fuel boilers, solid fuel boilers, and HCl production furnaces), the baseline is set at the "current, existing" levels shown in the first table of Appendix C, and described above.

The second table in Appendix C shows emissions estimates for the ISR baseline. It includes, for each Source ID and each HAP: (1) emissions reduction percentages required to meet the baseline – for Phase I sources, emissions reduction percentages from current, existing required to meet the Interim Standards Rule (ISR); for Phase II sources, zero reductions are required because current emissions are the same as baseline emissions; and (2) mass emissions rate associated with the baseline stack gas concentrations.

For compliance with the ISR, the emission reduction percentage for a given HAP is determined as the ratio of the difference of the HAP's ISR "design level" (DL) and the HAP's baseline emission concentration to the HAP's baseline emission concentration. The DLs, as presented and discussed in Chapter 2, are an estimate of the level that a source is expected to target to meet the full MACT emissions standard, considering variability due to source operations and stack gas measurement methods. For the ISR, DLs are estimated by borrowing the ratio of the DL and full standard determined for the MACT Replacement Rule for the specific HAP and source category.

3.3.3 MACT Options

The final set of tables in Appendix C show for each MACT Replacement Rule option presented in Chapter 2, and for each system ID and each HAP: (1) reduction percentages from baseline ISR required to meet the MACT floors; and (2) mass emissions rates when meeting the MACT floors.

As discussed above, the emission reduction percentage for a given HAP is calculated as the ratio of the difference of the HAP's MACT standard DL and the HAP's baseline emission concentration (shown in the previous section of this chapter) to the HAP's baseline emission concentration.

3.4 Phase II Area Source / Major Source Determination

Title III of the Clean Air Act requires that "major sources" of hazardous air pollutants (HAPs) meet MACT emission standards. Additionally, area sources (sources which do not meet the major source definition described below) may be regulated under the MACT standards if EPA finds that the sources "present a threat of adverse effects to human health or the environment (by such sources individually or in the aggregate) warranting regulation under this section." (see Section 112(c)(3)). The CAA defines major sources as:

> "Any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year

or more of any combination of hazardous air pollutants."

This section identifies Phase II HWC units that are projected to potentially meet the "area" or "major" source criteria.

3.4.1 Facility Annual Emissions

Annual baseline emission rate estimates for all facilities in the universe of Phase II HWC sources are derived from the HAP emission data presented above. To obtain the aggregate emissions for each HAP and facility (one or multiple systems per facility sharing the same EPA ID), emissions from all systems with identical EPA IDs are added for each HAP. For example, many facilities have multiple boilers located at the same site.

Non-PCDD/PCDF organic HAP emissions are estimated for solid boilers, and liquid and HCl Production Furnaces using emissions factors for coal and fuel oil from EPA's AP-42 Emissions Factor Compilation Document:

- Fuel oil -- For fuel oil, non-PCDD/PCDF organic HAPs are estimated at 0.05 lb/1000 gal (equivalent to stack gas concentration of 2.64×10^{-8} lb/ft3 @ 7% O_2). The primary HAP contributors are formaldehyde, benzene, toluene, and naphthalene, and other polycyclic organic materials. This level is fully consistent with an estimate based on the total non-methane organics emission factor of 0.20 lb/1000 gal and a typical fraction of 25% of total organics as organic HAPs which has been observed from hazardous waste incinerators (which ranged from 10-30%).

- Coal -- For coal, non-PCDD/PCDF organic HAPs are estimated at 0.01 lb/ton coal (equivalent to a stack gas concentration of 3.1×10^{-8} lb/ft3 @ 7% O_2). This is based on: (1) emissions factors for specific organic HAPs; and (2) a total non-methane organics emission factor of 0.05 lb/ton coal and a typical fraction of 20% of the total organics as organic HAPs.

A summary of the emission estimates per facility is presented in Appendix E for all Phase II HWC units. For each facility, this table includes the name, location, EPA ID, and total HAPs and individual HAP emissions in tons per year.

3.4.2 Area Source Determination

Facilities with HWC unit stack gas emissions of either greater than 25 tons of all HAPs, or greater than 10 tons of a single individual HAP are "major" sources. These are identified in the table of Appendix E. These are major sources based solely on emissions from on-site hazardous waste combustors.

The remaining Phase II HWC facilities are classified as either "possible" or "likely" area sources. Major and area source status is determined by the entire facility's HAP emissions --

from HWCs as well as those from any other HAP emission sources at the site. Facilities are classified as “possible” area sources when HWC unit emissions are less than the major source criteria, however it is not likely that the facility as a whole is an area source because of significant contributing HAP emissions from other on-site processes -- in particular, when the HWC sources are located at large manufacturing complexes. It is projected that all but 3 of the area sources are “possible” area sources -- where it is most likely that all but 3 of the sources would be classified as major due to emissions contributions from other process operations. This determination is made based on the name recognition of the facility, likely size, expected magnitude of HAP emissions from other on-site process operations, and survey of EPA Regional offices on the Title V permitting status of the facility.

Sources not identified as “major” or “possible” area sources are identified as “likely” area source facilities. These sources are located at sites which are likely to have overall total HAP emissions at levels less than that required for major source classification.

4.0 Engineering Costs

This chapter discusses engineering retrofit cost estimates for HWC sources to achieve the various MACT options presented in Chapter 2.

4.1 Cost Estimation Procedure

4.1.1 Determine Emissions Reductions Required to Meet MACT Replacement Rule

For each system, emissions reductions from baseline levels (ISR for Phase I, current for Phase II) that are required for each HAP to meet the MACT Replacement Rule options are determined. The procedures used to set-up the baseline levels are described above. Procedures used to estimate levels that must be obtained to comply with the MACT Replacement Rule options are identical to those described above for complying with the Interim Standards Rule.

4.1.2 Select Retrofit Controls Required to Meet MACT

On an individual system-by-system basis, a least-cost control strategy is selected which is projected to provide compliance with the entire suite of individual HAP MACT standards – retofits to reduce emissions from baseline levels to MACT Replacement Rule required levels. The control method(s) may involve: (1) HAP hazardous waste feedrate control; (2) upgrade of existing air pollution control equipment; and/or (3) the addition of new air pollution control devices. The selection depends on both the HAP emissions reductions that are required (calculated in the previous step), as well as the current set-up of the system (existing air pollution control devices used):

- None: If the percent reduction is zero for a given HAP, no additional retrofit or control upgrade is required for that HAP. If the percent reduction for all HAPs is zero, then no additional upgrades (and therefore, no costs) are required to meet the MACT option.

- Retrofit/Upgrade: If the percent reduction for a HAP is greater than zero, additional control, either through retrofit/upgrade of existing control equipment or addition of a new air pollution control system/device, is required. As mentioned above, the control strategy that is selected to reduce emissions to the MACT Replacement Rule standards is based on the type of existing control equipment, the type of HAP requiring control, and the level of reduction(s) required. Control strategy actions are categorized into either Design, Operation, and/or Maintenance (DOM) of existing equipment, or installation of new equipment:

    -- Design/Operation/Maintenance (DOM) modifications of existing equipment – If a HAP is controlled by existing air pollution control equipment, then "DOM" improvements may result in emission reductions necessary to meet the MACT Replacement Rule option. In these cases, DOM improvements are generally considered in two categories – "small" or "moderate" – depending on the degree of reduction in emissions that is required:

- <u>"Small" DOM</u>: If the reduction in the emissions required is less than 25% (between 0 and 25%), a "small" DOM for existing equipment is used. A small DOM consists of a minor redesign or modification to existing equipment.

- <u>"Moderate" DOM</u>: If the reduction in emissions required is between 25% and 75%, a "moderate" DOM to existing equipment is used. A moderate DOM typically consists of a major redesign or modification to existing equipment.

-- <u>Installation of New Equipment</u>: A new control device is required if either:

- No existing device currently in use at the source is capable of controlling a HAP requiring emissions reductions (i.e., HAP percent reduction is greater than 0, and no control device that controls the HAP is currently used).

- Required emissions reduction is greater than 75%. A new control device is used if emissions reductions greater than 75% are required, even in cases where a source is using control equipment theoretically capable of controlling the HAP. For example, for a source with an existing FF that needs more than 75% reduction in PM, installation of a new FF is selected rather than upgrade of the existing FF. This assumption may overestimate costs in cases where the source is able to achieve more than 75% control (or achieve the standard) by performing a DOM on the existing equipment.

The selection of the specific retrofit control method(s) depends on the HAP that requires control. Specific upgrades include, for each HAP:

<u>Particulate Matter Control</u>

• <u>New equipment</u> -- When new equipment is required for PM control (due either to the source not having any existing PM control device, or a PM reduction of greater than 75% is required), a new FF is selected. A FF is selected because FFs generally have lower total annualized costs compared with comparably performing electrostatic precipitators (ESPs).

In cases where the source does not have any existing PM control device and relatively small amounts of additional PM control are required (specifically, the situation for a number of liquid fuel boilers), a new FF is selected over wet scrubbers or cyclones because:

-- The FF which is selected is a “polishing unit” (has a relatively high A/C ratio).

-- PM that needs control is expected to be fines (small diameter) for which wet scrubbers and cyclones are relatively ineffective.

Further, it is assumed that: (1) the FF can be placed in series directly behind any existing PM control device within a “dry APCD” system; and (2) the FF can be retrofitted directly into an existing “wet APCD” system, upstream of the wet scrubbing system. Depending on source-specific factors (such as flue gas temperature leaving the combustor and the existing flue gas cooling system, equipment, and physical layout), additional flue gas cooling equipment (e.g., water quench or air dilution) may be required in order to integrate the new FF upstream of the existing wet scrubber system. Note that a wet ESP or IWS may be less costly to incorporate for certain existing wet systems that require additional PM control because wet ESP or IWSs can be added directly onto the back end of the existing wet scrubbing system. In such cases, the selection of a FF may overestimate the costs compared with a wet ESP or IWS.

- PM APCD Upgrades --

  -- FFs -- For FFs, small upgrades (SDOM) involve improved O&M practices and the use of opacity or bag leak detections systems. Moderate upgrades (MDOM) are achieved through replacement of bags with improved, higher efficiency, fabric material.

  -- Dry ESPs -- For dry ESPs, small upgrades (SDOM) involve improved O&M practices and use of PM CEMS. Moderate upgrades (MDOM) are achieved with the use of flue gas conditioning (humidication), higher power input, sectionalization, and/or automatic voltage control systems. Large upgrades are achieved with the addition of extra fields.

  -- High energy wet scrubbers -- Upgrades (both SDOM and MDOMs) involve increasing the pressure drop of the scrubber system.

  -- Ionizing wet scrubbers and wet ESPs – Dry ESP upgrades are used to represent upgrade costs for IWS or wet ESPs.

PCDD/PCDF Control

- Temperature control of existing “dry” PM control device -- Reducing the operating temperature of a dry particulate matter control device reduces PCDD/PCDF emissions. For estimating costs, a factor of 10 reduction in PCDD/PCDF emissions results from a 150°F reduction in temperature, valid over a temperature range of 350 to 750°F.

- Activated carbon injection or carbon beds -- To achieve additional PCDD/PCDF control beyond that achievable with temperature control, either activated carbon injection or an activated carbon bed is selected.

For medium and large sized units, activated carbon injection is selected. Carbon beds are selected for smaller sources. Note that:

- Activated carbon injection can not be performed immediately upstream of a wet PM control system (i.e., the carbon must be captured in a dry particulate matter control device).

- The application of activated carbon injection or carbon beds downstream of a wet system requires flue gas reheat to a temperature above the dew point.

- The application of activated carbon injection for cement and lightweight aggregate kilns requires the addition of a separate additional polishing fabric filter dedicated to capturing the activated carbon (i.e., the carbon can not be injected into the primary existing FF or ESP since it would contaminate the kiln dust, preventing the dust from being recycled back into the kiln or mixing it with the final aggregate product). For other source types, activated carbon can be caught in existing FF or ESPs.

Hg, SVM, LVM, and Chlorine

Hg, SVM, LVM, and chlorine are reduced through "feed control" of the hazardous waste – where feed control involves reduction of the amount of HAP fed to the combustor system.

Ideally, the feed control would have two cost components:

- Lost revenues due to waste not fired -- Applicable to "commercial" hazardous waste combustors, as:

  -- *Transferred costs*. Hazardous waste not burned at one facility will be transferred and burned at another facility. One facility's lost revenues from this transfer are another facility's gain. Although these are real costs/revenues to the individual facilities, they are insignificant to the industry as a whole.

  -- *Non-transferred costs*. The quantity of hazardous waste generated will be reduced due to waste minimization and pollution prevention. These are costs to both the individual facilities and to the industry as a whole.

- Costs to implement feed control -- To implement feed control in the hazardous waste, a facility (either itself, or indirectly through its supplier) will incur costs such as those for increased analysis, blending, and transport.

To adequately assess the cost of feed control, the following is required:

- Revenue for waste feed ($/ton) -- This is likely a function of waste type (solid, liquid, heating value, etc.) and of waste content (e.g., mercury concentration).

- Amount of total waste reduction required to achieve a proportional amount of feed control -- Because facilities typically fire a number of different wastes of varying metals/chlorine concentrations over the course of a year, it is likely possible to achieve a substantial reduction in feed rate of a particular HAP with a small reduction in total feed rate. If detailed normal waste concentration data were available, the waste reduction required could be estimated. This may be a function of facility type (e.g., small on-site units may not have many waste streams) and of baseline waste concentration (e.g., facilities which already have low feed rates may not have high-concentration waste streams to selectively control).

An analysis of the cost of feed control of metals and chlorine in the hazardous waste based on lost revenues is not possible because data on the quality and composition of hazardous waste feeds is both insufficient and uncertain.

Instead, an alternative approach is used to estimate the cost of feed control of metals and chlorine in the hazardous waste. The approach is based on the estimate that the upper limit of hazardous waste feed control cost would not exceed the cost of a technology retrofit to control the HAP. This is realistic because a facility would not likely use feed control if controlling the HW feed would cost more than a technology retrofit. This approach places an upper bound (conservative) estimate on the feed control cost. It also can be used to quantitatively assess differences in cost effectiveness between various beyond-the-floor options.

Specifically, the cost of feedrate control is assumed to be a fraction of the full cost of control based on an air pollution control device technology add-on retrofit – where the fraction is taken from the % required reduction of the HAP to meet the MACT Replacement Rule standard. For example, if 5% Hg reduction is required, the estimated feed control cost would be 5% of the cost of the control technology for Hg (for example, for a cement kiln, a new activated carbon injection and polishing fabric filter). When control requirements are based on a DOM of existing equipment, feed control costs are assumed to increase linearly as a function of the emission reduction percentage within each of the emission reduction ranges.

It is assumed that there is one “feed control” cost for controlling SVM or LVM, and that the cost is determined based on the maximum emission reduction required to meet the MACT Replacement Rule option for the two metal groups. For example, if a source needs a reduction in LVM of 37% and SVM of 63%, then the feed control cost of SVM and LVM would be assessed based on the higher percent reduction needed -- 63%. The cost is then apportioned over the two metal groups based on the percent reductions needed. For example for the case above, if the estimated feed control cost is $100,000, the SVM feed control cost would be $63,000 and the LVM cost would be $37,000. This approach assumes that controlling the HW feedrate to reduce SVM emissions will also reduce LVM emissions in a similar proportion; which is reasonable because actions to control the feedrate of SVM and LVM are similar and will likely have the same general effect on both types of metals

<u>CO, HC, and DRE</u>

Combustion modifications and afterburners are used to control CO, HC, and DRE.

4.1.3 Determine Costs of Air Pollution Control Retrofits

Cost models are used to estimate the costs of the new equipment installations and/or DOM modifications described above. Appendix J contains documentation of each cost model used for the analysis -- including models for both new equipment and existing equipment DOM upgrades. Some of the cost models are taken from the EPA's "OAQPS Control Cost Manual" (1990) and EPA's "Handbook: Control Technologies for Hazardous Air Pollutants" (1991). In some cases the cost models were modified and updated to meet the specific needs of these analyses. In cases where cost models are not available for a specific type of air pollution control device, models are developed based on discussions with and literature from pollution control equipment vendors.

The inputs to the cost models include the size and stack gas characteristics of the individual HWC system, the characteristics of the air pollutant to be controlled, and control technology design parameters.

The outputs of these models are: (1) total installed equipment capital investment cost; (2) annualized capital cost; (3) annual operating and maintenance costs (including utilities, labor, and replacement parts); and (4) total annualized costs (sum of annualized capital and annual operating and maintenance costs). Additional, non-air requirements, including water usage, waste water generation, electricity, and fossil fuel usage are also estimated.

4.1.4 Cost Effectiveness

The engineering "cost per HAP" ("cost effectiveness" (CE)) is determined as the ratio of the total annualized cost to meet the MACT Replacement Rule option that is attributable to the specific HAP ($/yr) to the amount of HAP reduced (tons/yr).

Some control devices that are selected are effective at controlling more than one HAP. In these cases the following hierarchy is used to assign control costs to specific HAPs:

- Costs of control devices used for PCDD/PCDF, such as activated carbon or polishing FFs, are attributed fully to PCDD/PCDF. Controls selected for PCDD/PCDF provide control at no-cost for other pollutants that are incidently controlled, such as Hg with activated carbon; or PM, SVM, and LVM with a new polishing FF.

- Costs of control devices used for PM are attributed fully to PM. Controls selected for PM provide no-cost, incidental control of SVM and LVM up to the PM control reduction on a one-to-one basis (e.g., a PM control reduction requirement of 35% provides 35% no-cost, incidental control of SVM and LVM).

- SVM/LVM feedrate cost is apportioned over the two metals groups based on the SVM and LVM percent reductions that are needed.

Cost effectiveness for beyond-the-floor (BTF) evaluations is determined as the ratio of the difference between the costs to meet the floor and BTF, and the difference between the emissions reductions from the floor to BTF.

For a few of the BTF options, controls required for the HAP(s) for which a BTF level is selected (BTF HAPs) provide incidental, no-cost control for other HAPs for which a BTF level was not selected (non-BTF HAPs). This results in a control cost for non-BTF HAPs at the BTF option that is lower than the cost at the floor option. To avoid calculating a CE for the non-BTF HAP for the BTF option that is lower than the CE for the non-BTF HAP at the floor option, the control cost at the floor for the non-BTF HAP is substituted for the control cost at the BTF. The difference between the cost at the floor and the initial cost at the BTF is subtracted from the cost for the BTF HAP. This effectively preserves the same overall cost to the BTF option, while fixing the cost for non-BTF HAPs at the BTF option to be the same as the cost at the floor option.

4.5 Results

4.5.1 Engineering Costs

Engineering cost results are shown in the tables of Appendix D for the series of MACT Replacement Rule options presented in Chapter 2:

Table Name	Option
OPT1F	Option 1 Floor
OPT1D	Option 1D Beyond the Floor
OPT1E	Option 1E Beyond the Floor
OPT2F	Option 2 Floor
OPT2D	Option 2D Beyond the Floor
OPT2E	Option 2E Beyond the Floor
OPT3F	Option 3 Floor
OPT3D	Option 3D Beyond the Floor
OPT3E	Option 3E Beyond the Floor
ISR	Interim Standard Rule

Cost estimates are provided for each individual system. Each table has the same format and content:

- Source ID Number
- % reductions required to meet the MACT standards for each HAP.
- Air pollution control device retrofits that are projected to be needed to meet each of the HAP MACT standards. The following acronyms are used:

  CB: carbon bed
  CI: activated carbon injection
  DS: dry scrubbing
  ESP: electrostatic precipitator
  FF: fabric filter
  HEWS: high energy wet scrubber
  LEWS: low energy wet scrubber
  MDOM: medium design, operating, and maintenance improvement
  SDOM: small design, operating, and maintenance improvement
  Q: water quench cooling

- For each HAP (and the total for all HAPs), estimated total annualized cost (TAC) and annualized capital cost (AC) for the engineering retrofits to meet the MACT standards. Annual operating and maintenance cost is the difference between the TAC and AC.

A series of additional summary tables (each starting with "SUMM") are also included at the end of Appendix D. The tables provide a summary of the total costs and emissions reductions for each HAP for each of the six HWC source categories and for each of the regulatory scenarios.

4.5.3 HAP Cost Effectiveness

The summary tables at the end of Appendix D also show the cost effectiveness for each HAP and source category. The cost effectiveness for each HAP is determined as the ratio of the total annual cost attributable to the HAP for all sources in the source category and the total amount of HAP emissions reductions for all sources in the source category. Note that the cost effectiveness is shown from the baseline to the floor or beyond the floor.

4.5.4 Individual HAP Achievability and Simultaneous Achievability

The summary tables in the back of Appendix D also show the percentage of systems per source category that meet each of HAP limits, considering the HAP design level (DL), as well as meeting the full (100%) standard. Also, the percentage of sources per category that simultaneously meet all of the MACT standards for each regulatory option are shown (again considering both the DL and full standard).

4.5.5 New Sources

Compliance costs to meet the MACT Replacement Rule for new sources are assumed to be zero. Control schemes to comply the Replacement Rule are anticipated to be similar to those that would be selected by new sources to comply with current regulations. Recent new sources have been consistently designed using the state-of-the art equipment for PCDD/PCDF, Hg, chlorine, and PM control – including activated carbon injection and carbon beds, fabric filters with membrane bags, wet electrostatic precipitators, packed bed wet scrubbers, etc. – that are capable of meeting the MACT new source emission requirements.

4.6 Beyond-the-Floor

Existing Sources

For each HAP and source category combination, the cost and emissions reductions of "beyond-the-floor" (BTF) standards are independently evaluated – in addition to the few selected beyond-the-floors that are evaluated as part of the previously discussed MACT options. The BTF levels that are considered and evaluated are based on the Option 1 MACT floor scenario.

Beyond-the-floor levels for existing sources are based on the following control technologies:

- Chlorine –
  - SFB and LWAKs – BTF control with "simple, direct duct injection" dry scrubbing provides 75% chlorine control. A control level of 75% is considered achievable with "simple, direct duct injection" dry scrubbing considering the chlorine floor levels for LWAKs and SFBs (600 and 440 ppmv), and typical variability in dry scrubbing performance. Wet scrubbing can provide increased control (greater than 95%), but it is not as cost effective as dry scrubbing for these source categories. Note that for LWAKs, it is assumed that an additional "polishing" FF is required to separately catch the dry scrubbing sorbent.
  - Others – For the other source categories, BTF control with wet scrubbing provides 50% chlorine control. A control level of 50% is selected considering the chlorine floor levels (< 10 ppmv). Wet scrubbing control efficiency decreases as the inlet chlorine level decreases.
- Hg – BTF control with activated carbon provides 70% control for all source categories.
- PM, SVM, LVM –

- For source categories with PM floors in the 0.015 to 0.03 gr/dscf range (incinerators, cement kilns, lightweight aggregate kilns, and liquid fuel boilers), state-of-the-art fabric filters are selected to provide 50% additional BTF PM control.

- For solid fuel boilers with a floor of 0.06 gr/dscf, BTFs of both: (1) 50% control using conventional fabric filters; and (2) 75% control using advanced fabric filters.

• <u>PCDD/PCDF</u> –

- For source categories with numerated PCDD/PCDF floors equal or less than 0.4 ng TEQ/dscm (incinerators, cement kilns), BTF with activated carbon to a BTF level of 0.1 ng TEQ/dscm.

- For source categories with numerated PCDD/PCDF floors above 0.4 ng TEQ/dscm (liquid boilers with dry APCDs), or with non-enumerated projected equivalent floors above 0.4 ng TEQ/dscm (HCl production furnaces with a projected PCDD/PCDF floor of 3 ng TEQ/dscm, and lightweight aggregate kilns with projected PCDD/PCDF floor of about 6 ng TEQ/dscm), BTF with activated carbon to a BTF floor level of 0.4 ng TEQ/dscm. Additionally, for HCl production furnaces, a BTF level of 0.2 ng TEQ/dscm based on the use of activated carbon beds is evaluated.

- For source categories with non-enumerated PCDD/PCDF floors that are projected to be less than 0.4 ng TEQ/dscm (liquid fuel boilers without dry APCDs, solid fuel boilers), BTF with activated carbon to a BTF level of 0.1 ng TEQ/dscm.

Additional beyond-the-floor control methods that are evaluated include:

• <u>Feedrate control</u> – For metals and chlorine, separate BTF levels based on feedcontrol ("FC") are evaluated. A feedcontrol-based BTF reduction of 20% is used for all feed controlled HAPs and all source categories.

• <u>Activated carbon</u> – The use of activated carbon for the simultaneous, combined control of both Hg and PCDD/PCDF.

Results of the BTF analyses are summarized in Appendix F. There is a separate table for each HAP. Each table contains: (1) floor and BTF level considered; (2) floor and BTF control basis; (3) emissions reductions and total annual cost of complying with the BTF and floor; (4) BTF cost effectiveness, determined as the ratio of the differences in floor and BTF compliance costs and emissions reductions; and (5) non-air impacts of the floor and BTF standards.

<u>New Sources</u>

Beyond-the-floor analyses for new sources are shown in the series of tables in Appendix G. There is a separate table for each HAP. The BTF levels are based on the Option 1 MACT floor scenario. Beyond-the-floor equipment, costs, emissions reductions, and cost effectiveness are shown for two “model” sources – an average sized unit, and a small unit. The cost of the BTF for each model plant is determined as the difference between the projected control equipment needed to meet the floor and the control equipment needed to meet the BTF.

5.0 Testing, Monitoring, Recordkeeping, and Reporting Costs

This chapter discusses additional, non-engineering related compliance costs of the HWC MACT Replacement Rule, including those from requirements for performance testing, monitoring, and recordkeeping and reporting.

The compliance costs represent those beyond (additional, incremental from) that required by existing RCRA BIF regulations that are currently applicable to Phase II HWCs and the ISR requirements for Phase I HWCs. Incremental costs are determined by estimating the total cost of complying with the HWC MACT rule and subtracting out the cost of complying with the present RCRA BIF regulations or ISR.

Tables in Appendix I summarize additional testing, monitoring, recordkeeping, and reporting cost estimates associated with the HWC MACT replacement rule for Phase I and Phase II sources, respectively. Costs are shown for an individual system. Costs are included for the following items:

- Reading new rule.
- Notification of Intent to Comply, and Progress Reports
- Compliance Testing. Comprehensive and confirmatory compliance testing.
- Continuous Emissions Monitoring Systems
- Automatic waste feed cutoff (AWFCO) reporting
- Compliance testing date extension request
- Compliance testing wavier request
- Operator Certification and Training Program
- Operating and Maintenance Plan
- Startup, Shutdown, and Malfunction Plan
- Emergency Safety Vent Plan
- Feedstream Analysis Plan
- Continuous monitoring systems (CMS) and continuous emissions monitoring systems (CEMS) recordkeeping, reporting, and quality assurance activities
- Alternative PM standard request
- Miscellaneous recordkeeping and reporting

These cost estimates apply to each individual, unique combustion system. For facilities (sites) with multiple systems, there may be some cost sharing and savings, thus, costs may be somewhat overestimated.

6.0 Non-Air Environmental Impacts

The HWC MACT Replacement Rule standards provide a direct impact (reduction) on hazardous air pollutant emissions from hazardous waste combustion sources. The MACT standards will also produce other non-air environmental impacts. Water, solid waste, and energy impacts will result as a use of air pollution control equipment and as a result of shifts in waste treatment and waste minimization activities. Tables in Appendix H shown non-air impacts for the Option 1 floor for existing sources, BTF options for existing sources, and BTF options for new sources.

6.1 Water Impacts

Increased water usage and waste water generation occurs as a result of additional flue gas cooling, conditioning, and wet scrubbing requirements to meet the HWC MACT standards.

6.2 Solid Waste Impacts

Retrofit controls added to meet the PM MACT standard will increase the amount of solid waste (fly ash) that is collected. Additional solid waste will be generated from the use of dry scrubbing sorbents and activated carbon.

6.3 Electricity

The addition of new air pollution control devices and/or modification of existing devices to meet the HWC MACT standards will increase electricity consumption (primarily through the use of pumps, fans, and feeders).

6.4 Fossil Fuel

Fossil fuels (particularly natural gas) are required in stack gas reheaters and afterburners.

Also, as discussed in detail in this rules Regulatory Impact Assessment, there are some on-site combustion units that are projected to stop burning hazardous wastes to avoid complying with the HWC MACT standards. Many of these units are likely to treat the waste in other on-site or off-site units. Alternatively, they may also likely send the waste for use in hazardous waste burning cement or lightweight kilns. Some may also go to commercial hazardous waste incinerators. In the cases where the waste is currently incinerated, and now will be sent to energy recovery units, there will be a reduction in overall fossil fuel usage due to potential reallocations of hazardous waste from on-site combustors to other units which recover and use the energy of the waste.

6.5 Waste Minimization Benefits

It is projected that some hazardous waste might be reallocated from current HWCs to waste minimization alternatives in response to the price increases stimulated by the HWC MACT Replacement Rule. Further, hazardous waste diverted from combustion systems that stop burning may be managed under waste minimization alternatives.

6.6 Other Non-air Health and Environmental Benefits

The MACT standards will provide reduction of HAPs that are persistent in the environment due to there potential to bioaccumulate, and their toxicity to humans and the environment. These include Hg and other toxic metals, PCDD/PCDF, and other non-PCDD/PCDF organics.

7.0 Miscellaneous Issues

7.1 Particulate Matter Size Distribution

Particulate matter size distribution (PSD) in the stack gas of hazardous waste combustors varies depending on the air pollution control device design and operation (ESP, FF, venturi scrubber, etc.), feedstream composition (ash content), and combustor system design.

- Cement kilns – Typically 40-60% of total stack gas PM by weight is less than 2.5 um in size. Based on PSD measurements risk burns and CoC testing from six hazardous waste burning CKs, and that reported from non-hazardous waste CKs (from AP-42).

- Coal boilers -- Typically 40-70% of total PM by weight is less than 2.5 um in size. Based on data from non-hazardous waste burning coal fired boilers (from AP-42), and very limited data from hazardous waste burning coal boilers.

- LWAKs -- 60% of total PM by weight is less than 3.5 um in size. Based on non-hazardous waste burning LWAK data (from AP-42), and performance of similar systems with similar air pollution control practices (other high temperature mineral processing kilns that use fabric filters).

- Incinerators -- Physical form of waste has a strong influence on PM size distribution:

    -- Liquid waste incinerators: Greater than 90% of total PM by weight is less than 2.5 um. Based on data from a couple of liquid waste incinerators, and fuel oil combustors (from AP-42).

    -- Solid waste incinerators: Greater than 70% of total PM by weight is less than 2.5 um. Based on data from a couple of solid hazardous waste burning incinerators.

- Liquid fuel boilers -- Greater than 90% of total PM is less than 2.5 um. Based on data from a number of liquid hazardous waste burning boilers.